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ABSTRACT

The relationship between learning ability and intelligence has continually been a focus of theory and research. It is argued in this paper that the inconclusive results of studies relating individual differences variables such as intellectual abilities to learning are due to a too pragmatic, theoretical orientation. Theoretical models explicating the role of individual differences constructs are examined in a developmental context and compared with empirical efforts to cross-link components of intelligence and learning. In contrast to earlier evaluations, this review suggests that cross-linkages are often meaningful, systematic, and interpretable and that they may form the building blocks for inclusive conceptualizations of intellectual development which pay attention to both treatment and individual differences variance. (Author)

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LEARNING AND INTELLIGENCE: A REVIEW OF EMPIRICAL AND THEORETICAL ISSUES

by

Gisela Labouvie-Vief

Report from the Project on
Children's Learning and Development

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Statement of Focus

Individually Guided Education (IGE) is a new comprehensive system of elementary education. The following components of the IGE system are in varying stages of development and implementation: a new organization for instruction and related administrative arrangements; a model of instructional programing for the individual student; and curriculum components in prereading, reading, mathematics, motivation, and environmental education. The development of other curriculum components, of a system for managing instruction by computer, and of instructional strategies is needed to complete the system. Continuing programmatic research is required to provide a sound knowledge base for the components under development and for improved second generation components. Finally, systematic implementation is essential so that the products will function properly in the IGE schools.

The Center plans and carries out the research, development, and implementation components of its IGE program in this sequence: (1) identify the needs and delimit the component problem area; (2) assess the possible constraints—financial resources and availability of staff; (3) formulate general plans and specific procedures for solving the problems; (4) secure and allocate human and material resources to carry out the plans; (5) provide for effective communication among personnel and efficient management of activities and resources; and (6) evaluate the effectiveness of each activity and its contribution to the total program and correct any difficulties through feedback mechanisms and appropriate management techniques.

A self-renewing system of elementary education is projected in each participating elementary school, i.e., one which is less dependent on external sources for direction and is more responsive to the needs of the children attending each particular school. In the IGE schools, Center-developed and other curriculum products compatible with the Center's instructional programing model will lead to higher student achievement and self-direction in learning and in conduct and also to higher morale and job satisfaction among educational personnel. Each developmental product makes its unique contribution to IGE as it is implemented in the schools. The various research components add to the knowledge of Center practitioners, developers, and theorists.

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I
Introduction

Cronbach's (1957) classic article deploring the lack of communication between multivariate-correlational and univariate-experimental methodologies has not stifled debates over the relative merits of the study of individual differences variance and the study of treatment variance. In general, the investigation of apparently convergent constructs still proceeds along two rather divergent routes, and there is little interchange between proponents of either method (Baltes & Nesselroade, 1973; Coffield, 1970). Research on the development of intellectual behavior dramatically illustrates this point. On the one hand, there is the psychometric tradition (Guilford, 1967; Horn, 1970) with its emphasis on the description of covariation patterns among multiple performance measures and its use of derived inter-individual differences dimensions such as factors or traits. Learning approaches, on the other hand, have studied the development of single behaviors in controlled situations and have concentrated on the analysis of antecedents and processes involved in the ontogeny of intellectual behaviors. So far, there has been little integration of these two areas.

Recently, a number of theoretical and empirical contributions (Anastasi, 1970; Baltes & Labouvie, 1973; Baltes & Nesselroade, 1973; Ferguson, 1954; Fleishman, 1972; Fleishman & Bartlett, 1969; Labouvie, Frohring, Baltes, & Goulet, 1973; Liverant, 1960; Roberts, 1968-69; Staats, 1971; Whiteman, 1964) have deplored this schism and stated that a rapprochement between traditional learning and psychometric models of intelligence might considerably advance the understanding of intellectual processes. Such an attempt at integrating the two models could have a dual advantage. First, it might aid in moving the traditional, highly pragmatically oriented intelligence concept away from its primarily descriptive, one-sided context (Baltes & Nesselroade, 1973; Gewirtz, 1969) by suggesting a theoretical framework specifying the antecedents and processes involved in the acquisition of intellectual performance. Second, it might suggest to the researcher involved in developmental learning processes the utility of a multimeasured assessment of ontogenetic changes in learning performances.

Such a multivariate orientation appears highly desirable since, as Emmerich (1973) has convincingly argued, questions of changes in response-interrelationships, rather than in univariate parameters, are often at the core of developmental theorizing. Consider, for instance, a suggestion that has recently emerged from the literature on developmental learning processes (Flavell, 1970; Jensen, 1971; White, 1965). This view proposes that the many different changes isolated in discrete learning and memory tasks converge into an interrelated set of ontogenetic progressions, namely, the increasingly effective use of cognitive-mediational devices in learning situations. Such a proposition would receive considerably more validity if it were based on systematic attempts to conceptualize learning tasks within a unified framework spelling out which classes of strategies relate to specific categories of learning tasks (Gagné, 1967; Jensen, 1967; Fleishman, 1972).

The proposition that the traditional multivariate and learning approaches to the study of intellectual behavior have some concepts in common is, in fact, not a new one. It has been a long-standing conviction that intelligence and learning ability are closely related constructs (Fleishman & Bartlett, 1969; Guilford, 1967; Stevenson, Hale, Klein, & Miller, 1968). The impact of this conjecture has increased considerably with the recent upsurge of efforts to prevent and modify the debilitating effects of cultural deprivation. Since such attempts necessitated the formulation of theoretical models linking intellectual abil-

ities to their experiential antecedents, an increasing number of theoretical contributions propose the explication of the intelligence construct in terms of the cumulative and interactive effect of learning experiences (Baltes & Labouvie, 1973; Bijou, 1971; Ferguson, 1954; Fowler, 1969; Gagné, 1968; Hunt, 1961, 1969; Staats, 1971; Whiteman, 1964).

Originally, the concern for a rapprochement between classical learning and ability research was motivated by the recognition that an exclusive emphasis on univariate experimental research may prevent the formulation of general behavioral laws. That is, individual differences parameters cannot, and should not, be treated as "noise" or error variance but may have a moderating effect on the validity and acceptability of general theoretical statements. Thus, a number of authors have argued that a consideration of individual differences as "initial states" will point out the limits of general behavioral laws and that the incorporation of individual differences parameters will increase the predictive power of such lawful statements (Coffield, 1970; Cronbach, 1957; Gagné, 1967; Glaser, 1967). A prime example of this approach is the vast literature relating learning effectiveness to such variables as IQ, social class, ethnicity, or other demographic categorizations (Cattell, 1971; Zeaman & House, 1967; Jensen, 1969, 1971; Rohwer, 1970; Stevenson, 1970) in an attempt to define training conditions that might be optimally suited to the characteristics and needs of specific subgroups.

In the absence of a theoretical focus, however, such a concentration on aptitude by treatment interactions (Cronbach & Snow, 1969; Salomon, 1972) has not generated a great deal of enthusiasm among researchers. The major reason for this lack of appeal may be their reluctance to accept trait like constructs as explanatory mechanisms per se (Anastasi, 1970; Baltes & Nesselroade, 1973; Mischel, 1968). Thus, while it is descriptively valid to state that subjects' locations on a number of trait dimensions will determine their reactions to a particular event (Mischel, 1971; Cattell, 1966)—a statement vividly demonstrated by Allport's (1937) words, "The same fire that melts the butter hardens the egg [p. 102]"—recent spokesmen of the multivariate tradition have argued that it will be necessary to explicate such inter-individual differences structures (Anastasi, 1970; Baltes & Nesselroade, 1973; Baltes & Labouvie, 1973; Mischel, 1968) by framing inter-individual differences variables in terms of the process constructs of contemporary theories of learning and performance (Melton, 1967, p. 239).

The present paper, consequently, examines the extent to which the linkage between individual differences dimensions of intelligence and learning performance can be theoretically integrated within a developmental framework. Specifically, the purpose of this review is threefold: (1) to provide a synopsis of current theoretical formulations of the developmental interaction between learning and abilities, (2) to present an evaluative review of current research evidence on this topic, and (3) to formulate some implications for future research of the view developed in this paper.

II
Theoretical Formulations of Learning-Ability Interrelations

An attempt to align intelligence components and learning performance must necessarily start out with a taxonomy of those ability dimensions that may interact with various modes of learning. This task of identifying the exact structural features of intelligence has been a point of contention among theoreticians from the psychometric current (e.g., Burt, 1949; Cattell, 1963; Guilford, 1967; Horn, 1970; Spearman, 1939; Thurstone & Thurstone, 1941; Vernon, 1950). Many recent writers, however, agree that an "adequate" structural model needs to be able to account for at least two points: (1) the differentiated nature of mature intelligence, and (2) the fact that the emergence of this multidimensional structure undergoes ontogenetic transformations (Anastasi, 1970; Baltes & Nesselroade, 1973; Horn, 1970; Reinert, 1970). Hence, the formation of covariation patterns between abilities and learning becomes itself an ontogenetic phenomenon and poses two theoretical questions that are examined below (Anastasi, 1970; Buss, 1973). The first of these involves the explication of the developmental processes involved in the formation and organization of intellectual abilities. The second, in turn, concerns the interaction of acquired abilities with subsequent learning.

Formation and Ontogenetic Organization of Abilities

Although there is a host of literature dealing with attempts to demonstrate covariations between intellectual processes and molar environmental conditions, such as sociocultural or child-rearing variables (for recent summaries see Bayley, 1970; Horn, 1970; Jensen, 1969; Reese & Lipsitt, 1970), the specific processes by which intellectual abilities are shaped have not been very well highlighted. This is not surprising since, as Gewirtz (1969) has argued, the global level of analysis utilized in such studies is not appropriate for demonstrating laws of learning that deal with specific functional relationships. Therefore, if one accepts Liverant's (1960) position that "the behavioral realm typically ascribed to intelligence (is) within the confines of modern learning theory [p. 109]," it becomes imperative that intellectual ontogeny be discussed in terms of the acquisition of certain behavioral skills as a function of specific environmental input patterns.

At the same time, however, the requirement for specificity in a functional analysis has been a hindrance to the rapprochement between S-R and psychometric domains of intelligence (Whiteman, 1964). Traditional learning approaches have been intraproblem oriented in their description of growth aspects of specific responses in specific stimulus settings (Gagné, 1968; Goulet, 1973; Stevenson et al., 1968). With the rising interest in cognitive aspects of learning, however, there has been an increasing emphasis on the development of higher-order skills (Goulet, 1973) which assume a status of generality compatable to that of the ability concept (Staats, 1971).

At present, most authors view the development of such broad behavioral repertories of higher-order skills as a relatively late achievement; it is thought to be built upon the acquisition of progressively more complex behaviors in the form of a hierarchically ordered cumulative sequence of learning processes (Gagné, 1968, 1970; Ferguson, 1954, 1956; Fowler, 1969; Jensen, 1969, 1971; Staats, 1971). Jensen has succinctly summarized the assumptions of such cumulative learning models

> . . . the sets of habits which we identify as intelligent behavior are seen as being built up through the acquisition of habits and chains of habits which interact to produce complex behavior.

> Mental development is thus viewed as the learning of an ordered set of capabilities in some hierarchical or progressive fashion, making for increasing skills in stimulus differentiation, recall of previous learned responses, and generalization and transfer of learning [Jensen, 1971, pp. 39-40].

Transfer notions thus form an important ingredient in most attempts to cross-link learning with intellectual ontogeny (Anastasi, 1970; Baltes & Nesselroade, 1973; Carroll, 1966; Gagné, 1968, 1970; Ferguson, 1954, 1956; Fowler, 1969; Jensen, 1971; Staats, 1971; Whiteman, 1964). Gagné (1970) has suggested that it may be useful to distinguish between two ways in which learning may facilitate subsequent acquisitions. The first, lateral transfer, refers to the facilitative effect of having learned one specific response on the learning of related responses. An example of lateral transfer is Staats' (1971) description of how a child learns to respond to verbal instructions as responses are reinforced in the presence, but not in the absence, of verbal commands. After a number of such experiences in diverse situations, the child establishes reliable attention to verbal cues. On a more general level, Harlow (1959) has discussed the operation of lateral transfer in terms of the acquisition of learning sets: the formation of "learning how to learn" consists, essentially, in cumulative nonspecific transfer from one discrimination problem to the next. Thus, the quantitative increase in a given performance (e.g., quickness in solving each new set of problems) is, in fact, accompanied by the formation of a strategy that has intersituational applicability.

Once a learning strategy has been firmly established this way, it may be used as a prerequisite for further, more advanced skills. This process of vertical transfer is exemplified by Staats' (1971) example, where the establishment of attentiveness to adult verbal instructions is a prerequisite for the learning of more complex skills. Similarly, Gagné (1968; see also Fowler, 1972) has applied a cumulative learning point of view to the mastery of conservation problems. According to Gagné, the mastery of such relatively complex problems is the result of a slow developmental progression that moves in a hierarchy from simple S-R connections and chains through multiple discriminations, concepts, simple rules, and, finally, complex rules.

In general, cumulative learning models assume that the principles and environmental arrangements related to inter- and intra-individual differences in cognitive repertories all apply to the developmental learning of a variety of abilities (Fowler, 1969). It is necessary, then, however, to account not only for the parallel emergence of different ability systems, but for their covariation patterns as well. That is, since abilities are identified simply in terms of responses clustering in a factor, we need to attempt to consider the source of such co-occurrence.

Traditionally, of course, the pet interpretation has been that abilities represent basic, intrinsic sources of individual differences (Jensen, 1967). However, the conceptualization of abilities identified in factor analysis as relatively enduring—though ontogenetically fluctuant—qualities, or even endowments, of the individual has become increasingly criticized (Anastasi, 1970; Baltes & Nesselroade, 1973; Carroll, 1966; Mischel, 1968) since it fails to fully account for cogent interpretations in terms of differential learning experiences.

Following Carroll (1966), it may be useful to distinguish between three additional, experience-related sources of correlation between response classes. The first of these is operative when the learning of one response is based on the learning of a prerequisite skill, as is the case in hierarchical learning sequences. Whiteman (1964), for instance, has applied such an analysis to the acquisition of learning sets and has argued that a factor might represent nothing but differential exposure to problems of a particular nature. The second major approach similarly relies on the concept of transfer (although lateral); here, the assumption is that the breadth versus specificity of transfer effects determines the degree to which ability systems are either general or specific. For instance, although many intellectual skills may be based upon similar prerequisite skills, positive transfer may be limited by a particular symbolic medium (Fowler, 1969). Thus, as Ferguson (1954) states, "we may account for a component general to many abilities in terms of the operation of positive transfer, and for the differentiation of abilities in terms of the learning process itself, which... operates in such a way as to facilitate differentiation [p. 110]." This approach is also discussed by Anastasi (1970), Baltes and Nesselroade (1973), Carroll (1966), and Staats (1971).

Note that both of these interpretations do not necessarily reject the notion of task-intrinsic processes; they do, however, add a developmental flavor by allowing for their ontogenetic transformations. The third source of covariation does not raise any claim to a process interpretation, but may simply arise if "because of the common experience of certain numbers of [a] group of persons, there

was a higher probability that both of any pair of responses were learned together than that either would have been learned alone [Carroll, 1966, p. 408]." Consequently, high or low correlations between responses or abilities may merely reflect the degree of differentiation of learning experiences (Anastasi, 1970; Baltes & Nesselroade, 1973; Carroll, 1966; Tryon, 1935), and an ability identified through factor analysis should not be interpreted as indicating an intrinsic process without considerable theoretical underpinnings and/or a related set of antecedent conditions.

Interaction Between Abilities and Learning

From a cumulative learning point of view, then, intellectual abilities are interpreted as sets of well-learned cognitive-mediational operations that generalize across a broad range of situations. Staats (1971), for instance, states that "intelligence test skills may be considered to sample parts of basic behavioral repertoires . . . [which] constitute a basic set of skills for the acquisition of further intelligence skills [p. 43]." Hence, the transfer notion implies that abilities are not only a product of past learning but also serve to facilitate (or interfere with) new learning: "Any learned capability, at any stage of the learning sequence, may operate to mediate other learning [Gagné, 1968, p. 186]." The availability of a set of strategies that may be transferred to any new learning situation is, in fact, seen to constitute "a genuine and measureable aspect of the learner's intellectual ability [Gagné, 1968, p. 189]." Crucial questions then arise as to what the nature of these skills is and how they are modified by and interact with new learning.

With respect to the definition of the nature of the relevant skill systems, the key element contained in cumulative learning formulations is the proposition that ability tests provide a sample of the major learned behavioral repertories or strategies (Staats, 1971). Such a viewpoint suggests the utility of identifying the nature of those repertories by a systematic cross-mapping of those processes and learning skills that play an important part in both ability and learning performance. Thus, since any ability is assumed to assess the degree of pre-experimental acquisition of a group of strategies, one would expect that distinct covariation patterns would emerge between those abilities and learning performances that show a high overlap of basic skills (Ferguson, 1954; Jensen, 1969, 1971).

As an example, consider Jensen's (1968, 1969, 1970, 1971) proposition that both abilities and learning tasks can be classified along a continuum with rote processes (Level I abilities) at one end and abstract conceptual processes (Level II abilities) at the other. In Jensen's terminology, Level I abilities refer to mental processes that involve little elaboration of stimulus inputs; this results in high correspondence between stimulus input and response output. Thus, such diverse indices as performance on digit span and other rote memory tests—e.g., serial recall as well as certain forms of free recall and paired-associates learning (under conditions not conducive to elaboration)—should tap Level I processes predominantly and, as a consequence, should intercorrelate (and fail to intercorrelate with Level II measures). Level II processes, on the other hand, involve elaboration and transformation of stimulus inputs. Consequently, tests of abstract reasoning should intercorrelate with learning performance in tasks that are highly conducive to certain kinds of elaborative activity—a prediction that tends to be confirmed by recent experimental evidence (Jensen & Rohwer, 1970; Labouvie et al., 1973).

At the same time, however, it should be realized that cumulative learning models ultimately require a less static conceptualization of learning-ability interrelationships. Since abilities are conceptualized as transfer variables that constitute the foundation for new subsequent acquisitions, the interaction between ability and learning performance is one of constant change. That is, while at any point of ontogeny abilities provide a measure of previously learned skills, they are continually modified by later experience. Thus, as learning proceeds—be it in an ontogenetic context or in an experimental situation—differential processes (skills) may come into play that reflect the progression from simple to more effective complex strategies. The covariation patterns between learning performances and abilities should, therefore, show progressive changes as learning proceeds.

In this context, Jensen's Level I-Level II distinction, originally proposed to account for differences in learning-ability covariations as a function of socioeconomic level, appears to provide a useful vehicle for generating predictions about changes in learning-ability covariations as well. That is, if Level I and Level II abilities are interpreted as referring to hierarchically related developmental levels (as implied by Jensen [1971], as well as by Gagné [1968] and Staats [1971]) one would expect changes in covariation patterns between learning tasks and abilities as a func-

tion of ontogenetic progression. Thus, as the individual progresses in the hierarchical learning sequence, performance in a task may be related to rote type skills early in ontogeny while at a later point the same task may reflect the use of Level II abilities. Moreover, to the extent that Level II processes can be trained, practice-related changes in such covariation patterns should essentially parallel those found naturally in groups of different developmental and/or socioeconomic levels (Jensen, 1971).

Ultimately, of course, such a duo-process conceptualization of changes in learning-ability patterns presents only a simplified picture. First, we know from the psychometric literature that adolescent and adult intelligence are characterized by a high degree of differentiation (Baltes & Nesselroade, 1973; Horn, 1970; Reinert, 1970). Second, the large variety of ontogenetic changes subsumed under the label "mediational strategies" makes one wonder if they are aptly summarized by one single rote-conceptual continuum (Rohwer, 1970). Consequently, the next chapter will include a review of empirical research that may have implications for the isolation of a number of basic skills, for the tracing of their developmental modifications, and for the demonstration of the effect of modifications in the nature and number of skills on covariation patterns between learning and abilities.

III
Aligning Components of Intelligence and Learning: Empirical Contributions

Ideally, the demonstration of a mutual interdependence of ability and learning performance should be based, as indicated earlier, upon an identification of processes and/or basic mechanisms (Jensen, 1967; Melton, 1967) which produce patterns of intercorrelations among performance parameters. As argued in the previous chapter, however, there is a dearth of unifying frameworks of this kind. As a consequence, research in this area has been guided by model-oriented conceptions to a negligible extent; most research has taken a descriptive and exploratory stance.

In general, these studies were not explicitly oriented toward the examination of learning-ability interactions in a developmental context. Rather, they concentrated on descriptive attempts toward structuring and cross-relating the universe of both ability and learning tasks. The general assumption of this research, however, was that learning-ability relationships indicate the degree of acquisition of broad conceptual systems, that is, abilities, which may transfer to any particular learning situation (Ferguson, 1954, 1956). Accordingly, the potential implications for the ontogeny of learning-ability covariations are of an indirect nature, and will be spelled out in Chapter IV.

Structuring the Covariation of Learning and Abilities

Many of the original studies of learning-ability interactions were intended to test the conjecture that intelligence and learning ability are closely related concepts. This assumption proved to be rather simplistic. That is, intelligence does not constitute a unidimensional construct, nor is there a unitary process permeating all learning. In fact, intercorrelations between different kinds of learning tasks typically proved discouragingly low (e.g., Husband, 1939, 1941; Roberts, 1968-69; Stevenson et al., 1968; Stevenson & Odom, 1965), thereby suggesting the existence of a number of separate inter-individual differences dimensions in learning performance.

A series of dissertations from Princeton University (Allison, 1960; Bunderson, 1965; Duncanson, 1964; Manley, 1965; Stake, 1961) reported attempts to identify such individual differences dimensions in learning tasks in terms of known ability marker tests. These studies were often based on the notion that learning tasks could be located on an associative-conceptual continuum (i.e., rote vs. concept learning) and therefore involved some preliminary hypotheses about the formation of common factors among the samples of learning tasks and ability markers used. In general, this research has demonstrated a number of factors confined to either the ability or the learning domain, but the cross-relationships turned out to be rather few and poorly replicable.

A few of the cross-linkages that have been obtained are, however, worth noting. A quite consistent finding, for instance, was that paired-associates tasks, originally assumed to tap rote processes, tended to correlate with both reasoning and memory factors (Duncanson, 1964, 1966; Stake, 1961). On a more global level, this result has been substantiated by Stevenson and associates (Stevenson et al., 1968; Stevenson & Odom, 1965); they found that IQ most consistently correlated with paired associates and with verbal and figural rote memory tasks. As Rohwer (1970) notes, however, this finding is hardly surprising since it is known that paired-associates learning involves a rich amount of mediational activity.

Concept learning has also been matched with ability markers, although the results are somewhat more equivocal. Both Stake (1961) and Duncanson (1964), for instance, were not

able to detect any substantial loadings of their concept learning tasks on any of the common ability factors. Stevenson et al. (1968) and Ste enson and Odom (1965) similarly reported low correlations between concept-formation tasks and IQ. However, both Allison (1960) and Bunderson (1965) found cross-relations involving, among others, a loading of concept tasks on reasoning tests. Lemke, Klausmeier, and Harris (1967) also found that concept attainment and information processing tasks were consistently correlated with performance on tests of general and inductive reasoning (see also Dunham & Bunderson, 1969). Generally, however, the results of these studies present a rather complex and inconclusive picture.

According to Jensen (1967), this inconclusiveness is the result of two severe deficiencies of a conceptual nature: (1) the absence of models defining the structure of learning tasks and (2) the lack of theories specifying the linkage between the structure of learning tasks and ability structure. The first deficiency indicates the need to conceptualize a universe of learning performances, or phenotypes—defined by variations in tasks characteristics, treatment parameters, stages of practice, etc.—and to attempt to structure this universe in terms of sets of pervasive processes and mechanisms, or genotypes. Such a unifying theory of learning is not presently available (see also Stevenson et al., 1968). Rather, structural analyses of individual tasks and the processes involved in their solution are offered; but the generalizability of such processes across tasks is rarely examined.

The absence of a structuring of genotypes has, according to Jensen (1967), resulted in a wide sampling of phenotypes from the learning domain with a very sparse sampling of tasks defining a particular genotype. As a result, hypothesized factors have tended to be "underdetermined," resulting in both a lack of common factors of learning tasks and a lack of interpretable learning-ability relationships.

Moreover, the lack of such models has resulted in a rather haphazard sampling of abilities (see also Dunham, Guilford, & Hoepfner, 1968). In fact, one is often overwhelmed by the sheer amount of ability markers that are sampled more or less arbitrarily from the intelligence domain with only meager attempts to justify their relevance to the learning tasks included. This procedure has tended to produce a confusing multitude of relationships that are difficult to interpret in an ad hoc fashion. Thus, one must concur with the assessment of Dunham et al. (1968) that research into learning ability cross-linkages will profit from an orientation toward model building and hypothesis testing. This will require a concentration not merely on the description of learning-ability covariation patterns but also on attempts to manipulate such patterns by incorporating treatment parameters and hypotheses about treatment effects on learning-ability interactions.

Alterations of Learning-Ability Covariations

The criticisms of Jensen (1967) and Dunham et al. (1968) of the prevalent mode of attempting to define cross-linkages between learning tasks and ability dimensions carry an important message. In many ways, this field of research would be more promising if it were less ambitious in attempting to answer all questions in a single study but proceeded in a programmatic, step-by-step fashion by formulating hypotheses of how specific learning tasks align with a restricted set of abilities. Unlike many of the earlier efforts, such approaches would also have to center on a more careful consideration of task variations (as well as their interaction with age and/or practice) that have an effect on modifying learning-ability covariation patterns. As Ferguson (1954) postulated two decades ago, this means that the factors related to individual differences under a specified treatment condition or stage of learning may not be related, or may be related in a different way, to performance in another condition or stage of learning.

As an example, consider the notion (implicit in many of the pioneer studies on learning-ability covariations) that paired-associate learning should tap rote processes and, consequently, should tend to covary with psychometric tests of rote memory. Such a statement is meaningless unless the specific conditions (task and subject-related) under which paired-associate learning is assessed are identified. Thus, we know that in adult subject populations this task is one that involves a rich amount of abstract conceptual activity; at the same time the ease with which such conceptual activity is induced varies considerably with parameters such as age, stage of acquisition, mode of presentation, and instructional variations (Reese, 1970; Rohwer, 1970). Consequently, one would expect a fluctuant relationship between any task category and a selected set of abilities although one that follows a law pattern.

It is important, then, to realize that studies that attempt to experimentally modify

learning-ability covariation patterns are of particular significance for understanding the formation of such relationships. This is particularly true if such modification attempts are conceptualized in a developmental framework, that is, if the nature of treatments is such as to simulate naturally occurring conditions (Baltes & Goulet, 1971). As Anastasi (1970) has stated, "such studies provide a condensed and relatively controlled version of what probably occurs more gradually, over a longer time period, in the individual's daily experience [p. 906]." Granted, such research will ultimately have to be supplemented by demonstrating that the observed changes are indeed isomorphic to naturally occurring developmental changes. However, since the parameter of age is a relative newcomer to the investigation of learning-ability cross-linkages, the following section will consider treatment and practice parameters first.

Practice-Related Changes

The most extensive work on changes in the covariation pattern between learning and abilities as a function of practice has been conducted by Fleishman and his associates (Fleishman, 1967, 1972; Fleishman & Bartlett, 1969). These studies were concerned with the relation of ability dimensions to various stages in the learning of complex psychomotor tasks. In general, the changes observed were characterized by (1) a shift in the contribution of specific abilities at different stages of practice, especially of nonmotor (e.g., verbal, spatial) to motor abilities, and (2) an increase in the contribution of factors specific to the training task itself. Thus, as Fleishman concluded, it seems that the correlational pattern increasingly reflects the contribution of those skills directly learned in the training tasks. A similar effect was also noted by Kohfeld (1966), who observed a decline in the contribution of verbal skills and an increase in the contribution of motor factors with increasing practice on a motor coordination task.

Three studies have concentrated on practice-related changes in learning-ability interactions in verbal learning tasks. Games (1962), relating a series of verbal learning tasks to rote and span memory factors, observed a shift in loading away from the span factor and toward the rote factor. Bunderson (1965) also found changes in factorial composition of concept formation tasks at different stages of practice. Specifically, perceptual speed and incidental memory contributed most strongly toward early learning, while inductive and general reasoning were more predictive at later stages. Finally, Dunham et al. (1968) examined performance in figural, symbolic, and semantic concept learning problems and their changing relationships to 15 reference factors. Again, systematic but quite complex changes in factorial composition were observed as learning proceeded.

Although they substantiate the notion of fluctuant interrelations between learning and abilities, these latter studies appear to lack conclusiveness. But Fleishman's and Kohfeld's results carry additional implications. First, they suggest that the process of age-related differentiation of the structure of abilities does indeed have an experiential basis, since the emergence of a factor specific to the training task itself corresponds to the mechanisms suggested by Anastasi (1970), Baltes and Nesselroade (1973), Ferguson (1954), and Tryon (1935). Second, they provide a clue to how specific learning experiences might be arranged in order to train a specific ability or class of abilities once the interrelationships between a set of learning tasks and specific abilities have been empirically mapped.

Although less comprehensively than in Fleishman's work, these conclusions have been substantiated by studies concerning the provision of training in traditional intelligence tests. Heinonen (1962) and Melametsa (1965) provided training on one test out of a battery and observed a subsequent differentiation of abilities. Anastasi (1936) provided mediational aids on three out of six ability tests. Her results indicated that the major share of individual differences variance (i.e., loadings on the strongest factor) before training appeared to be accounted for by pre-experimental school experience, while after training most of the variation could be explained in terms of the instruction procedure. Finally, Baltes and Nesselroade (1973) showed, via a computer simulation method, that factorial structure could be systematically manipulated: when individual differences in training were assumed to similarly affect all variables (as implied in the transfer notion as well as in Carroll's [1966] notion of contiguous experience), the intercorrelations rose and a single general factor emerged. Conversely, when training was response-specific, it was followed by a lowering of intercorrelations and a differentiation of factorial structure.

That research of this nature may indeed have relevance for the eventual training of specific abilities is suggested by a study by Khan (1972), who attempted to simulate naturally occurring developmental differences. One group of seventh graders received extensive training on a variety of verbal materials; the trained students subsequently showed a

verbal factor that was more similar to that of more experienced ninth and eleventh graders than to that of a control group. Since Khan's training was on test-related materials rather than on a specific test itself as in the previously cited studies, and since it was explicitly geared at simulating natural ontogenetic processes, this study perhaps most convincingly demonstrates the usefulness of cumulative learning considerations in the explication of abilities.

Treatment Factors and Their Interaction With Practice

In general, the studies mentioned above were predicated on the assumption that practice-related changes in factorial composition reflect the operation of different strategies or mediational skills at different stages of learning (Frederiksen, 1969). Another way to test this assumption is to attempt to directly manipulate these strategies by means of experimental treatments assumed to affect mediational behavior. This logic was followed in a study by Dunham and Bunderson (1969), who administered a series of concept problems under either decision-rule instruction or no-rule instruction conditions. This study is also notable for its selection of very few markers for memory and reasoning abilities. Although results did not show any treatment-related differences in acquisition per se, clear-cut differences in learning-ability covariation were found between the two treatment groups: associative memory and inductive reasoning were strongly related to performance under no-rule instruction, while induction and general reasoning were related to decision-rule instruction.

A few studies have looked at the interaction of treatment and practice parameters with changes in learning-ability covariations. Roberts (1968-69), for instance, administered a vocabulary learning task in which subjects learned word meaning either from synonyms or from dictionary definitions. Results showed that for the synonym group, the overall relationship of abilities and learning was initially positive and then declined; for the dictionary group, however, there was neither a significant overall relationship nor a notable trend.

Frederiksen (1969) designed a study based on the hypothesis that choice of mediational strategies, if manipulated by treatment parameters, would produce diverging trial-to-trial changes in the covariation pattern between a set of ability tests on the one hand, and a set of factor analytically derived learning response parameters on the other. A recall task was administered under three conditions: serial anticipation, free recall, and recall in clusters of five. Distinct patterns of covariation between learning and ability measures were demonstrated for each treatment group. Moreover, a significant overall relationship between abilities and learning existed for the free recall and clusters groups, but not for the serial anticipation group. These results, like those in the Dunham and Bunderson (1969) study were the more remarkable since no differences were obtained between the groups on the learning measures themselves.

The most systematic attempt thus far to formulate a priori the hypothesized relationship between mediational strategies and abilities was made by Labouvie et al.(1973) in a study utilizing free recall. A specific mediational process, subjective organization (Shuell, 1969; Tulving, 1962, 1968), was manipulated by both practice and timing of recall (delayed versus immediate). It was hypothesized that conditions producing a high amount of subjective organization would result in a high correlation between general reasoning abilities and free recall, while under conditions of low subjective organization, variables of the rote memory type would be more predictive. Since both practice and a delay between stimulus presentation and recall are known to enhance organizational activity (Atkinson & Shiffrin, 1968; Postman & Phillips, 1965; Shuell, 1969), two main hypotheses were formulated; one involved differential recall-ability relationships between immediate and delayed timing of recall, and the other involved changes in ability-recall covariation pattern as a function of stage of acquisition. Specifically, it was expected (1) that recall measures would show a strong relationship to general intelligence under delayed recall, while under immediate recall memory variables would show the strongest relationship to recall performance and (2) that the overall contribution of memory variables to recall performance would be strongest during early stages of acquisition, while at later stages the relationship with intelligence variables would increase.

The results of the Labouvie et al. study confirmed the predictions with surprising clarity. Thus, it appears justified to conclude that attempts to align learning processes and abilities may be successful if they are performed in a hypothesis-testing framework. In this study, the obtained interrelationships varied in a predictable and systematic manner; this is the more impressive since there were no treatment-related differences in amount recalled as a function of immediate versus delayed recall.

IV
Implications: Learning, Abilities, and Development

The quite clear-cut pattern of some of the data cited in Chapter III is in contrast to previous, rather pessimistic evaluations of attempts to cross-relate learning processes and ability test performance (e.g., Stevenson, 1970). It may be concluded from these data that the formulation of differential predictions about the interrelations between specific sets of abilities and learning performance under varying conditions may be a powerful tool in organizing learning-intelligence relationships. Thus, it appears justified to conclude at this time (1) that abilities can—in terms of their structural characteristics—be modified by the controlled provision of learning experiences, and that the observed changes appear to parallel natural ontogenetic trends, and (2) that under appropriate conditions interrelations between abilities and learning performance follow a law pattern and can be systematically manipulated by selected treatments.

These general trends are in agreement with cumulative learning conceptualizations of the formation of ability patterns and their subsequent interactions with learning (Gagné, 1968; Ferguson, 1954; Staats, 1971); hence, they suggest to the psychometrician the usefulness of attempting to move the traditional ability concept into a process-oriented framework by applying theory-related manipulations in the explication of individual differences concepts. Thus, the present author does not share the pessimism expressed by some (e.g., Bijou, 1971; Hunt & Kirk, 1971) who feel that the ability concept is being rendered obsolete. Such pessimism is justified only if, as has often happened (Anastasi, 1970), ability concepts are viewed as organismic state variables that have an autonomous and self-explanatory status. What, then, are the implications of the analyses presented here for future research geared toward a process-analysis of ability constructs?

Hypothesis-Oriented Experimental Research

A first set of implications concerns the need to design studies according to a model of learning-ability relations. In Jensen's (1967) view, the success in showing interpretable cross-domain linkages depends upon locating relevant genotypes that cut across both domains. At this early stage of our knowledge of cognitive-mediational operations that may mediate covariations between learning and abilities, the location of such genotypes may be most easily found by a sparse but hypothesis-oriented sampling of learning tasks and ability markers and by designing programmatic research that examines the effect of selected treatments on the alteration of interactions between learning tasks and abilities.

It is not surprising, therefore, that the most conclusive substantive findings emerge from research that has explicitly incorporated such theory-related manipulation; on the other hand, those studies that have sampled large numbers of learning task and ability markers without formulating hypotheses about covariation patterns present a rather confusing picture. A prime example of the former approach is Fleishman's (1972) programmatic research on the relationships between abilities and psychomotor learning which now spans well over a decade. Starting with systematic attempts to formulate a model for describing perceptual-motor performance, he has recently demonstrated meaningful interrelations between the ability variables thus defined and learning under different stages of acquisition with variations in task conditions. As Fleishman (1972) states, "It is now possible to specify the tasks that should provide the best measure of each of the abilities identified [p. 1019]."

In the area of verbal-learning, research has lacked this programmatic orientation. It

is the more encouraging, therefore, to observe the emergence of a few substantively meaningful patterns. Several studies report that tests of complex reasoning are of particular significance in learning that involves complex conceptual forms of mediation, while in learning which implicates rote type strategies to a larger extent, performance is predicted better from memory variables (Dunham & Bunderson, 1969; Jensen, 1969, 1971; Labouvie et al., 1973). The rote-conceptual dimension—inherent, in fact, in most cumulative learning formulations—may well form the starting point for a cross-mapping of processes in verbal learning and intellectual abilities. Thus, future research needs to systematically manipulate the choice of strategies in selected learning tasks and observe if these manipulations affect the covariation patterns between learning and abilities in the hypothesized manner.

Multi-Process Analysis of Convergent Learning Tasks

The task of aligning components of intelligence and learning performance requires that more explicit attention be given to the question of intertask relationships in the verbal learning literature. Thus far, analyses of intellectual development from a learning perspective have emphasized discrete tasks, with little concern for demonstrating a communality across various task settings (Stevenson et al., 1968). Thus, ontogenetic changes in the use of mediational strategies are typically inferred from changes in a single task parameter—effectiveness of learning in a particular task.

In this respect, the present discussion draws an important conclusion of a methodological nature: namely, that the validity of considering learning measures, taken under slightly different experimental conditions and/or stages of acquisition, as indicators of equivalent processes is questionable. As the Dunham and Bunderson (1969), Frederiksen (1969), and Labouvie et al. (1973) studies clearly indicate, a single performance parameter, such as number of correctly recalled items, is a rather insensitive index of the complex changes in underlying processes that may be induced by slight variations in task format. Rather, these studies show that learning performance assessed under different conditions may be structurally related to abilities in a strikingly different manner even if learning performance in all conditions is quantitatively identical. Thus, these data convincingly argue for the need to utilize multimeasured assessments of performance changes in learning tasks in order to locate change phenomena that are apt to be neglected if consideration is given to single performance parameters only.

Developmental Analysis of Learning-Ability Interactions

Since in most studies predictions of learning-ability interactions are derived from a cumulative learning framework, research needs to move explicitly into a developmental context. If the rote-conceptual distinction, for instance, is conceived to be a developmental one, the most explicit test of its validity can be performed in an ontogenetic framework by incorporating age as a treatment parameter.

In this context, it is interesting to note that the assumption of a hierarchical relationship between rote and conceptual-cognitive levels of functioning has indeed been the subject of a large number of contributions discussing the ontogeny of mediational skills (Flavell, 1970; Goulet, 1973; Kendler & Kendler, 1962, 1970; Reese, 1962; Stevenson, 1970; White, 1965, 1970). These discussions have found an age-related shift from a reliance on rote-type habits to higher-order strategies that mediate learning in a multitude of learning tasks, such as transposition problems (Kuenne, 1946; Reese, 1962), reversal shift paradigms (Kendler & Kendler, 1962, 1970; Slamecka, 1968), free recall (Laurence, 1966; Rosner, 1971), paired-associates learning (Paivio, 1969, 1970; Reese, 1965, 1970; Rohwer, 1970), and rehearsal strategies in memory tasks (Flavell, 1970).

If, as Flavell (1970) suggests, it is true that all of these changes—despite their apparent specificity—point to a general component of cognitive maturation, these findings have direct implications for the analysis of learning-ability interactions in a developmental context. Thus, within the multivariate framework of learning-ability correlation patterns, one would predict that reasoning abilities and general intelligence variables would be predictive of learning performance at the more advanced cognitive levels of adolescents and young adults, while memory abilities would show a higher relationship to learning of younger subjects who have a relatively high degree of mediational inefficiency.

Some preliminary research suggests, in fact, that these predictions may have some validity. Jensen (1970) found that paired-associates learning was more highly correlated with IQ in middle SES than in low SES kindergarten students. Glasman (1968),

directly varying age, found an even clearer differentiation: for kindergarten subjects, MA and free recall performance was uncorrelated (r = .06), while substantial correlations (r = .59) were obtained for fifth graders.

Finally, working with adult and aged subjects, Hultsch (1973) found recall performance consistently related to memory abilities in the older groups, while in younger subjects memory variables were predictive of early learning only—a finding concordant with the assumption that the elderly, much like the young (though because of different reasons [Goulet, 1973]), lack the spontaneous use of cognitive-mediational strategies.

Future research, therefore, should be directed at examining the proposition that there is indeed a general component involved in the variety of tasks analyzed in the developmental learning literature. As one proceeds in age, is it true that reasoning abilities become more predictive of a variety of learning tasks? Do these learning tasks themselves become more highly interrelated? Or will it be necessary to account for these changes by conceptualizing distinct classes of mediational skills—as Rohwer (1970) and Stevenson et al. (1968) as well as the demonstration of an increasingly differentiated ability structure suggest?

Educational Intervention and Evaluation

The present discussion has additional implications for aspects of educational intervention and technology. Bijou (1971) has forcefully argued that the conceptual planning of intervention into the course of intellectual ontogeny would be significantly advanced if the frames of reference for the theoretical analysis of intellectual processes and for educational engineering by means of application of learning principles were the same. Thus, in contrast to the still prevalent shotgun approach to modifying ability patterns, systematic theoretical efforts are called for in all attempts to link specific components to specific ability dimensions. The present findings suggest even further that such heuristic models must account for changes in learning-ability relationships as acquisition processes. Eventually, therefore, educational programs would need to be aimed at facilitating the operation of different ability components as task mastery progresses. Obviously, however, current knowledge of such task-ability-learning interactions is both vague and restricted in scope.

These considerations are also relevant for issues associated with the evaluation of educational interventions in terms of subsequent changes in ability scores. Consider, for example, the possibility that the somewhat discouraging results obtained in cognitive intervention research (e.g., Jensen, 1969) might be due largely to the failure of properly aligning, in the evaluation phase, learning and ability components. This seems particularly true if general measures of intellectual performance, such as IQ, are used as criteria in evaluating the effectiveness of educational programs.

Final Remarks

The present review adds considerable weight to Cronbach's (1957) early plea for a conceptual reconciliation between mainstream experimental research and the study of individual differences. A concentration on refining theoretical models linking the two should be of considerable help in advancing our understanding of the complexly interrelated processes that comprise intellectual functioning and intellectual development (Anastasi, 1970; Baltes & Nesselroade, 1973). In fact, such a theoretical focus appears essential to avoid much of the descriptive and empirical orientation of research into intellectual processes (Salomon, 1972).

The usefulness of the view presented here will ultimately depend on its capacity to generate conceptualizations of process variables that are both nontrivial and developmentally relevant. The ability to progress beyond overt, superficial similarities between learning performance and individual differences dimensions is, of course, not a guaranteed outcome of the methodological position advanced in this review. At least, however, such a multiprocess orientation appears to have considerable heuristic value in facilitating the generation of more inclusive models of intellectual functioning.

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